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The Eyes Have It: Contact Lens Impact on Performance of Armor Troops

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By

Bruce C. Leibrecht
William G. Bachman

Sensory Research Division
Visual Sciences Branch

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U.S. Army Aeromedical Research Laboratory
Fort Rucker, Alabama 36362-0577

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Reviewed:

Bruce C Leibrecht

BRUCE C. LEIBRECHT, Ph.D.
LTC, MS
Director, Sensory Research
Division

J D LaMotte

J.D. LaMOTHE, Ph.D.
COL, MS
Chairman, Scientific
Review Committee

Released for publication:

David H Karney

DAVID H. KARNEY
Colonel, MC
Commanding

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Contact lenses, particularly the extended wear varieties, offer an appealing alternative for solving equipment compatibility and environmental problems faced by spectacle-wearing soldiers. This paper presents performance results from the Army's first major field investigation of contact lenses.

The study evaluated extended-wear contact lenses in an operational armor environment. Male volunteers (N=311) from eight battalions of the 2d Armored Division at Fort Hood, Texas, wore contact lenses or spectacles for up to 6 months. They participated fully in their units' normal activities, including training in garrison and in the field. In response to questionnaires at the end of the study, nearly all of the contact lens wearers were highly or moderately confident in their ability to see adequately. Most felt they could see better with their contact lenses than with spectacles. The

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great majority indicated that contact lenses had improved their overall job performance, preferring contact lenses for a variety of military activities, operational settings, and environmental conditions. Environmentally induced difficulties related to wearing contact lenses were infrequent except for conditions involving dust, wind, and smoke. Contact lens wearers and spectacle wearers alike frequently reported lens-related difficulties in the field environment.

Together with the study's data on ocular physiology and wear and care problems, these results form the cornerstone of the database needed to support establishment of comprehensive Army policy for contact lens use.

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Bruce C. Leibrecht, LTC*
William G. Bachman, LTC
U. S. Army Aeromedical Research Laboratory
Fort Rucker, AL 36362-5292

Introduction

A large proportion of Army troops are myopic (nearsighted), hyperopic (farsighted), and/or astigmatic. These troops generally require visual correction, since good vision is essential for maximum combat effectiveness. Spectacles provide the standard means for visual correction. Yet spectacles are minimally compatible or outright incompatible with many military systems. Examples of these systems include weapons sights, night vision goggles, head mounted displays, binoculars, and protective masks. In addition, Mother Nature compounds operational problems with rain, sweat, dust, and condensation clinging to spectacle lenses of troops operating visually coupled equipment.

To accommodate the spectacle wearing soldier, visually coupled systems frequently incorporate "dial-in optics." The soldier simply dials adjustable optics, which are part of the system, to obtain corrected vision. Unfortunately, this approach compensates for only nearsightedness and farsightedness, not astigmatism. This shortcoming presents a serious limitation, since a high percentage of personnel requiring spectacles have varying amounts of astigmatism.[1] Of significance to the Army is that unresolved incompatibilities and environmental difficulties for spectacle wearing crewmembers can compromise system effectiveness and limit the manpower pool available for key systems.

Contact lenses, particularly the extended wear varieties, offer an appealing alternative for solving the compatibility and environmental problems faced by spectacle wearing soldiers. However, the published data documenting the impact of contact lenses on soldier performance are very limited.[2,3,4,5] There is a need to assess systematically the operational impact of contact lens wear. This issue is fundamentally important to the establishment of comprehensive Army policy for contact lens use.

In this paper, we present some of the data from the Army's first major field investigation of contact lenses.[6,7] At the time we initiated this study, soft contact lenses (CLs) worn for extended periods of time offered the greatest potential for Army applications. The armor environment provided an excellent setting, given the sighting devices found in M1 tanks and Bradley Fighting Vehicles. A major study objective was to assess the effects of contact lens wear on job performance and environmentally related aspects. Soldiers assigned to an armored division served as subjects while they participated fully in their units' normal activities. Questionnaires captured information on participants' experiences with job related activities, environmental factors, and operational settings.

Materials and methods

After screening candidates for medical suitability, we selected 311 volunteers to participate in the study; 215 wore extended-wear soft CLs for up to 6 months, while 96 served as spectacle-wearing controls. Ranging in age from 18 to 43, all were male soldiers (commissioned officers, noncommissioned officers, enlisted personnel) assigned to the 2d Armored Division located at Fort Hood, Texas. We excluded soldiers from wearing CLs if they had more than -6.00 diopters of myopia, more than +4.00 diopters of hyperopia, or more than 1.25 diopters of astigmatism. Thirty-five of the CL wearers were wearing their own soft CLs at the start of the study or had worn CLs within the preceding 6 months; we will refer to these as "experienced" wearers. Although the remaining CL wearers included 31 participants who had worn contact lenses at some point in the past, we will refer to this larger group as "inexperienced" wearers.

Most of the participants held duty assignments related to armor (M1 tank), mechanized infantry (M2 and M3 fighting vehicles, Improved TOW Vehicle, M106 mortar carrier), and air defense artillery (Redeye, Vulcan, Chapparal). About 20 percent were in support categories, including wheeled vehicle operations, maintenance, medical support, operations, logistics, and administrative support. The median time in the Army was 2.8 years for the CL wearers and 3.5 years for the spectacle wearers.

We used three different types of extended-wear soft CLs: 71 percent water content, 55 percent water content, and 38.5 percent water content. This mix provided high, medium, and low water content lenses in a variety of base curves for reasonably broad fitting capabilities. We instructed the CL participants to wear their lenses continuously for 7 days (plus or minus 1 day), then remove them for cleaning and disinfecting overnight. To guard against protein deposits building up on the lenses, we replaced all CLs after 4 months wear, or sooner if indicated.

During the course of the study, subjects participated without restriction in their units' normal activities, including training in garrison and in the field. We made no attempt to alter any unit's schedule. At the end of the investigation, participants completed a questionnaire addressing operational issues, responding primarily on the basis of their experiences in the study. We used separate questionnaires for CL wearers and spectacle wearers. Questionnaire items dealt generally with visual ability, job or task performance, and difficulties related to environmental factors or operational situations.

Results and discussion

In terms of effectiveness in correcting vision, the contact lenses we used were equal to spectacles. The same proportion of the CL wearers and the spectacle wearers (97 percent of each group) achieved 20/25 visual acuity or better. In practical terms, both groups were able to achieve comparable corrected acuities.

At the conclusion of the study, 135 inexperienced CL wearers, 25 experienced CL wearers, and 84 spectacle wearers had completed questionnaires. Not every individual answered every question. In interpreting the questionnaire results presented below, two tempering considerations are important. First, the corrective lens frame of reference for CL subjects was different than for spectacle wearers, since the latter had no experience with contact lenses. This may have skewed responses of spectacle wearers where relative judgments about acceptability, severity of problems, and so forth were required. Second, the CL wearers generally may have been motivated to present a favorable picture of the contact lenses. This could have influenced them to underestimate the frequency or severity of lens-related problems.

Nearly all of the CL wearers regarded their contact lenses positively, with 94 percent indicating they liked their lenses moderately or very much. This contrasts with 18 percent of the spectacle wearers who stated they liked their spectacles moderately or very much. The reasons reported most often for dislike were that spectacles got in the way and were uncomfortable, and that Army spectacles were ugly.

Both CL-wearing and spectacle-wearing participants were almost unanimously confident (99 percent and 96 percent, respectively) in their ability to see adequately. A large majority of the CL participants (77 percent of the inexperienced wearers, 92 percent of the experienced wearers) felt they could see better with contact lenses than with spectacles. The larger proportion of the experienced CL group in this category is consistent with their greater cumulative CL wearing experience, but also may reflect some self-selection. Only 6 percent of the CL wearers felt they could see better with spectacles than with contact lenses.

We asked the CL participants whether they could see better with contact lenses or spectacles for a variety of visually oriented tasks. These tasks included sighting/aiming and surveillance under different conditions. As Table 1 shows, the proportion of subjects judging they could see better with contact lenses exceeded 75 percent for most of the tasks. This held true for both inexperienced wearers and experienced wearers, the trend being slightly stronger for experienced wearers. The smallest proportions favoring contact lenses (62 percent of the inexperienced wearers, 68 percent of the experienced wearers) occurred for reading and writing. The reason for this most likely lies in the inconvenience of removing contact lenses when unaided vision might be appropriate for close-up work. Not surprisingly, nearly all of the CL

Table 1

Proportion of CL wearers judging task-related visual ability better with contact lenses or spectacles

	Inexperienced CL Wearers			Experienced CL Wearers		
Task	CL better	Spect better	No diff	CL better	Spect better	No diff
Sight/aim rifle	85%	3%	12%	82%	5%	13%
Sight/aim thru optics	91%	3%	6%	95%	0	5%
Surveillance						
- <1000m, naked eye	75%	9%	16%	88%	4%	8%
- <1000m, thru optics	85%	3%	12%	92%	0	8%
- >1000m, naked eye	69%	11%	20%	80%	4%	16%
- >1000m, thru optics	82%	5%	13%	88%	0	12%
Wear prot mask	95%	2%	2%	96%	0	4%
Read and write	62%	8%	29%	68%	8%	24%

subjects favored contact lenses when wearing protective masks. The proportion of respondents favoring spectacles for the various tasks did not exceed 11 percent for either group.

The great majority of the CL subjects (83 percent of the inexperienced wearers, 96 percent of the experienced wearers) agreed wearing contact lenses had improved their overall job performance; 3 percent felt it had not. Of the inexperienced CL wearers, 14 percent neither agreed nor disagreed that job performance had improved.

When we asked CL subjects to compare the relative benefits of contact lenses and spectacles in performing their duties, the response patterns seen in Table 2 emerged. For garrison duties, 82 percent of the inexperienced wearers and 96 percent of the experienced wearers felt contact lenses were at least somewhat better than spectacles. However, for field duties the judgments favoring contact lenses tended to be less strong. Only 2 percent of the CL participants felt spectacles were better than contact lenses for performing duties in garrison; this proportion climbed to 12 percent when field duties were considered.

Table 2

Proportion of CL wearers judging contact lenses vs. spectacles better for overall performance of duties

	Inexperienced CL Wearers		Experienced CL Wearers	
Response	Garrison	Field	Garrison	Field
CL much better	67%	58%	92%	68%
CL somewhat better	15%	20%	4%	28%
No difference	16%	8%	0	0
Spect somewhat better	<1%	7%	4%	0
Spect much better	<1%	7%	0	4%

To clarify the weaker ratings of CLs for field duties, we asked the CL participants if they had encountered difficulties while wearing their contact lenses during field training. Table 3 presents the response patterns and includes data for offduty and garrison settings as baseline conditions. Slightly more than one-third of both CL wearing groups reported lens-related difficulties in the field, compared to 7 percent or less in garrison and offduty environments. These difficulties frequently pertained to environmental factors (e.g. dust) or problems with cleaning the contact lenses. Nearly one in three CL subjects reported substituting their spectacles in place of contact lenses during field training. Significantly, 44 percent of the spectacle wearers reported lens-related difficulties during field training, compared to 15 percent in garrison. Fifty-three percent of the spectacle wearers stated they had avoided wearing their spectacles on occasion, usually during field training or physical fitness training.

Table 3

Proportion of participants reporting difficulties while wearing corrective lenses in selected settings

Setting	Inexperienced CL Wearers	Experienced CL Wearers	Spectacle Wearers
Offduty	7%	0	*
Garrison	5%	0	15%
Field training	34%	36%	44%

* Spectacle wearers were not queried about offduty difficulties.

Table 4 presents the proportions of participants reporting lens-related difficulties when performing various job-related tasks. The proportion of CL wearers noting difficulties did not exceed 8 percent for either the experienced or inexperienced groups. In contrast, spectacle wearing subjects reported substantial incidence of difficulties for several tasks, especially physical training and use of equipment requiring ocular compatibility (e.g. night vision goggles, protective mask). In response to separate items, two of every five spectacle wearers reported difficulty

sighting/aiming a rifle and sighting/aiming with optical devices. In parallel fashion, spectacle wearers frequently reported removing their spectacles to complete tasks for which difficulties commonly occurred (physical training, 35 percent; night vision goggle wear, 69 percent; night sight use, 51 percent). Among CL wearers, removal of contact lenses to complete a task was reported seldom (generally 2 percent or less of both inexperienced and experienced CL participants).

Table 4

Proportion of participants reporting difficulty performing tasks while wearing corrective lenses

Task	Inexperienced CL Wearers	Experienced CL Wearers	Spectacle Wearers
Read map	4%	0	6%
Shoot compass azimuth	2%	0	5%
Assemble indiv wpn	2%	0	4%
Drive vehicle	6%	4%	11%
Fuel vehicle	3%	0	6%
Maintain vehicle	5%	8%	16%
Use night sights	<1%	0	53%
Wear NVG	2%	0	75%
Don/use prot mask	4%	0	67%*
Perform PT	5%	0	39%
Read	7%	8%	5%
Write	4%	0	4%

* Protective mask worn with optical inserts.

Table 5 summarizes the results which emerged when we asked CL participants which corrective lens (spectacles or contact lenses) they preferred for performing various tasks. The proportion of inexperienced and experienced CL wearers preferring contact lenses never fell below 90 percent, except for a simulated combat exercise with minimum sleep, where the proportion was 83 percent for both groups. The latter may relate to CL participants' frequent reports of lens-related difficulties in the field, discussed above. As a whole, these results document a strong preference for contact lenses for all types of activities queried.

Table 5

Proportion of CL wearers preferring contact lenses vs. spectacles for performing various tasks

	Inexperienced CL Wearers			Experienced CL Wearers		
Task	CL	Spect	No pref	CL	Spect	No pref
Routine duties	92%	1%	7%	100%	0	0
Manual labor	93%	1%	6%	100%	0	0
Physical exercise	93%	2%	5%	100%	0	0
Sports activities	92%	2%	6%	100%	0	0
Vehicle ops	92%	3%	4%	100%	0	0
Veh fueling	89%	2%	9%	100%	0	0
Veh maintenance	92%	3%	5%	100%	0	0
Guard/patrol duty	92%	4%	3%	100%	0	0
Night gunnery	95%	3%	3%	94%	0	6%
Simulated combat	83%	11%	6%	83%	11%	6%

We asked all participants if a variety of environmental conditions made wearing their corrective lenses difficult. Figure 1 presents the resulting response patterns. A substantial proportion (greater than 25 percent) of the CL wearers reported lens-related environmental difficulties for only dust, wind, and smoke. Dry air and tear gas were also somewhat problematic for CL wearers. In contrast, among spectacle wearers the occurrence of environmental difficulties was substantial (more than 25% reporting) in 7 of 12 conditions queried. Especially problematic were rain

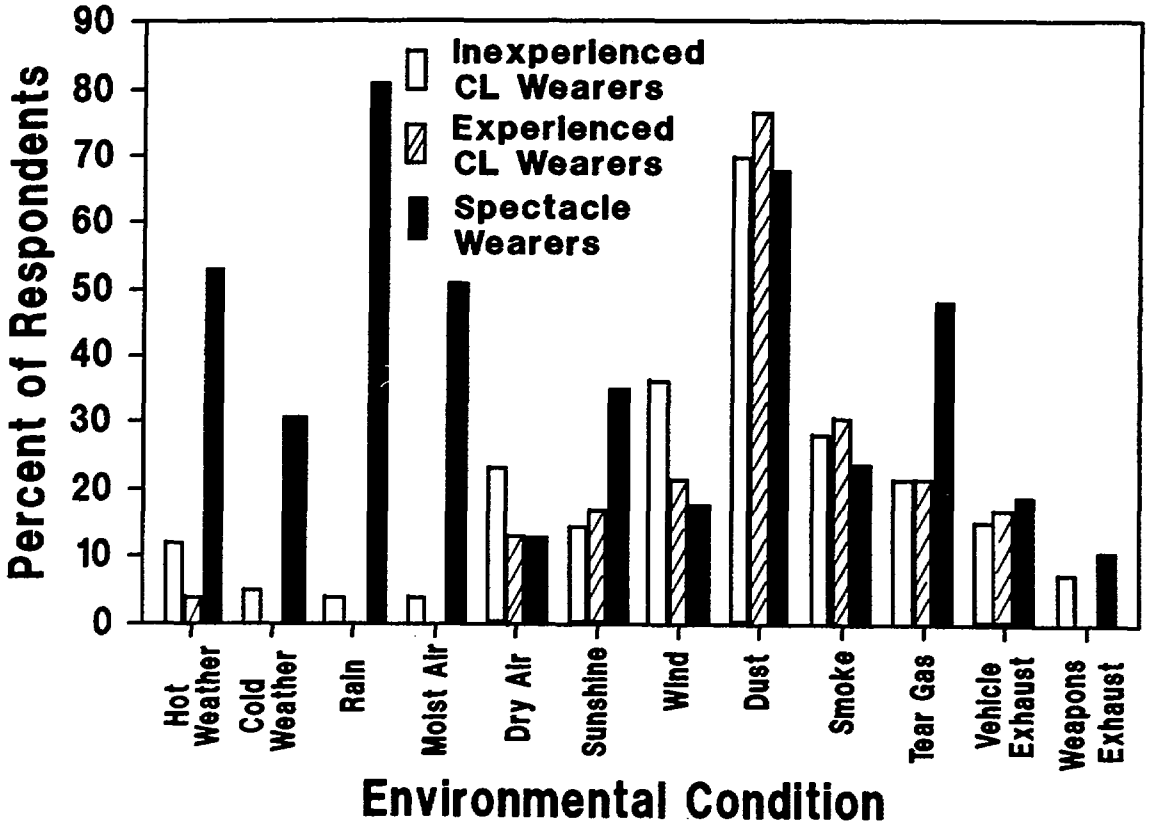

Figure 1. Percent of respondents reporting that various environmental conditions made wearing their corrective lenses difficult.

and dust (81 percent and 68 percent, respectively). The spectacle-related difficulties are understandable in terms of physical problems characteristic of spectacle lenses (rain or sweat streaking, fogging, dust coating, glare, etc.). We can relate the contact lens-related difficulties to ocular physiology (e.g. sensitivity to airborne substances and drying). Difficulties related to tear gas exposure during chemical defense training occurred less frequently among CL wearers than spectacle wearers. Kok-van-Aalphen et al.[8] have reported a similar finding in a study of policemen.

Appearing in Table 6 are the CL wearers' preferences for contact lenses or spectacles in the various environmental conditions queried. The proportion of subjects preferring contact lenses, based on experience during the study, was 70% or greater for every condition except dusty environments. In the latter case, preferences were split evenly between spectacles and contact lenses, with 15 percent of the inexperienced CL wearers expressing no preference. For both inexperienced and experienced CL subjects, the proportion preferring spectacles was less than 10 percent for every condition except dust, smoke, wind, and tear gas. This pattern of results is consistent with the trends for environmental difficulties presented above. Overall these findings reveal a strong preference for contact lenses for all environmental conditions queried, with the exception of dusty environments.

We asked the CL wearers to express their corrective lens preferences for a variety of military situations (e.g. airborne operations, combat operations), regardless of whether they had participated in the respective operations during the study. The resulting preference patterns appear in Table 7. For half the situations, 70 percent or more of the subjects preferred contact lenses. In the remaining cases, a substantial proportion of the respondents checked "don't know." If we remove these subjects from the analysis, the proportion of participants preferring contact lenses was less than 70 percent in only two cases -- airborne operations and air assault operations among inexperienced CL wearers. With "don't know" respondents excluded, 15 percent or less of the subjects preferred spectacles in every case except field training among inexperienced CL wearers (19 percent) and air assault operations among experienced CL wearers (21 percent). Although the judgments for the more rigorous military situations were based largely on estimates rather than actual experience, these findings demonstrate a substantial preference for contact lenses in all operational settings queried.

At the end of the study, nearly all of the CL participants (96 percent of the experienced wearers, 94 percent of the inexperienced wearers) wanted to continue wearing their contact lenses. Only 2 percent of the inexperienced subjects and 4 percent of the experienced subjects did not want to continue wearing their lenses.

Table 6

Proportion of CL wearers preferring contact lenses vs. spectacles in various environmental conditions

	Inexperienced CL Wearers			Experienced CL Wearers		
Condition	CL	Spect	No pref	CL	Spect	No pref
Hot weather	89%	3%	7%	100%	0	0
Cold weather	89%	3%	8%	100%	0	0
Rain	88%	1%	11%	100%	0	0
Moist air	87%	2%	11%	100%	0	0
Dry air	84%	9%	8%	94%	6%	0
Sunshine	88%	4%	7%	100%	0	0
Wind	70%	19%	11%	100%	0	0
Dust	42%	43%	15%	50%	50%	0
Smoke	72%	19%	9%	94%	0	6%
Tear gas	74%	21%	5%	75%	17%	8%
Veh exhaust	75%	7%	18%	89%	6%	6%
Wpns exhaust	79%	6%	15%	94%	0	6%

Table 7

Proportion of CL wearers preferring contact lenses vs. spectacles in various operational settings

	Inexperienced CL Wearers				Experienced CL Wearers			
Setting	CL	Spect	No pref	Don't know	CL	Spect	No pref	Don't know
Offduty	96%	2%	2%	0	96%	0	4%	0
Garrison	91%	3%	6%	0	96%	0	4%	0
Field trng	76%	19%	4%	0	92%	4%	4%	0
Deployment	72%	9%	4%	15%	84%	4%	4%	8%
Airborne ops	30%	5%	10%	55%	40%	8%	4%	48%
Air assault	34%	5%	10%	51%	40%	12%	4%	44%
Special ops	42%	5%	7%	46%	48%	4%	4%	44%
Combat ops	48%	9%	7%	35%	56%	4%	8%	32%

Conclusions

As the Army's first major evaluation of the performance impact of contact lenses, this study provides substantive findings relevant to the potential use of contact lenses among combat troops. Together with the study's data on ocular physiology and wear and care problems, the results reported in this paper form the cornerstone of the database needed to support establishment of comprehensive Army policy. The combined findings indicate the need for additional studies to address new types of contact lenses and specialized operational settings.

Based on the subjective performance findings obtained in the armor environment of this study, we conclude the following:

1. Contact lenses equalled spectacles in terms of participants' confidence in their ability to see adequately.

2. Contact lenses were judged superior to spectacles in visual ability afforded.

3. Contact lenses improved overall job performance for the great majority of CL wearers.

4. Difficulties related to wearing corrective lenses in the field were relatively common among both CL wearers and spectacle wearers.

5. Difficulties related to performing military tasks while wearing corrective lenses were infrequent among CL wearers, but frequent among spectacle wearers when equipment compatibility or physical exercise was involved.

6. Among CL wearers, lens-related environmental difficulties were infrequent except for conditions involving dust, wind, and smoke. Spectacle wearers more frequently reported environmental difficulties, especially for rain, dust, hot weather, and high humidity.

7. CL wearers expressed strong preferences in favor of contact lenses for performing military tasks, for most operational settings, and for diverse environmental conditions except dust.

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